PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 10104SG295/MHK/nbs	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. **PCT**/SG2005/000060	International filing date *(day/month/year)* 28 February 2005	Priority date *(day/month/year)* 27 February 2004

International Patent Classification (IPC) or national classification and IPC

Int. Cl.

G06T 7/60 (2006.01) ***G06T 7/40*** (2006.01) ***G06K 9/00*** (2006.01)
A61B 5/103 (2006.01) ***G03B 42/02*** (2006.01) ***G01N 23/083*** (2006.01)

Applicant

NATIONAL UNIVERSITY OF SINGAPORE et al

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of **6** sheets, as follows:
      [X] sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[ ]	Box No. VIII	Certain observations on the international application

Date of submission of the demand 22 September 2005	Date of completion of this report 30 January 2006
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer **Matthew Hollingworth** Telephone No. (02) 6283 2024

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/SG2005/000060

Box No. I Basis of the report

1. With regard to the **language,** this report is based on:

[X] The international application in the language in which it was filed

[ ] A translation of the international application into , which is the language of a translation furnished for the purposes of:

[ ] international search (under Rules 12.3(a) and 23.1 (b))

[ ] publication of the international application (under Rule 12.4(a))

[ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

[ ] the international application as originally filed/furnished

[X] the description:

pages **1, 5-25** as originally filed/furnished
pages* **2-4** received by this Authority on **22 September 2005** with the letter of **the same date**
pages* received by this Authority on with the letter of

[X] the claims:

pages as originally filed/furnished
pages* as amended (together with any statement) under Article 19
pages* **26-28** received by this Authority on **22 September 2005** with the letter of **the same date**
pages* received by this Authority on with the letter of

[X] the drawings:

pages **1-9** as originally filed/furnished
pages* received by this Authority on with the letter of
pages* received by this Authority on with the letter of

[ ] a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. [ ] The amendments have resulted in the cancellation of:

[ ] the description, pages
[ ] the claims, Nos.
[ ] the drawings, sheets/figs
[ ] the sequence listing *(specify)*:
[ ] any table(s) related to the sequence listing *(specify)*:

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

[ ] the description, pages
[ ] the claims, Nos.
[ ] the drawings, sheets/figs
[ ] the sequence listing *(specify)*:
[ ] any table(s) related to the sequence listing *(specify)*:

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/SG2005/000060

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	**1-23**	**YES**
	Claims		**NO**
Inventive step (IS)	Claims	**1-23**	**YES**
	Claims		**NO**
Industrial applicability (IA)	Claims	**1-23**	**YES**
	Claims		**NO**

2. Citations and explanations (Rule 70.7)

- D1: T. P. Tian et al, *Computing Neck-Shaft Angle of Femur for X-Ray Fracture Detection* Proc. Int. Conference on Computer Analysis of Images and Patterns, 2003, pp. 82-9
- D2: T. P. Tian, *Detection of Femur Fractures in X-Ray Images*, as archived July 2003 http://web.archive.org/web/20030727223836/www.comp.nus.edu.sg/~leowwk/thesis/tiantaipeng.pdf
- D3: D. N. Davis et al, *Diagnostic Classification of Leg Radiographs*, May 2000 http://www2.dcs.hull.ac.uk/NEAT/dnd/papers/tcamva.pdf
- D4: US 2003/0215119 A1 (UPPALURI et al), 20 November 2003
- D5: US 2003/0215120 A1 (UPPALURI et al), 2- November 2003

The above documents represent the closest available prior art, and do not anticipate the claimed invention. In particular, the documents do not disclose the use of adaptive sampling in bone fracture detection from X-ray images.

ray images for visual inspection. This method is, however, unsatisfactory because it can either remove important texture information (if the image is shrunken) or introduce noise and artifacts (if the image is enlarged).

Summary

In accordance with a first aspect of the present invention there is provided a method for detection of bone fractures using image processing of a digitised x-ray image, wherein the image processing comprises an adaptive sampling scheme.

The image processing may comprise extracting a contour of the bone in the digitised x-ray image.

The extracting of the contour of the bone in the digitised x-ray image may comprise applying a Canny edge detector to the digitised x-ray image.

The extracting of the contour of the bone in the digitised x-ray image may comprise applying a snake algorithm to the digitised x-ray image.

Applying the snake algorithm to the digitised x-ray image may comprise creating a Gradient Vector Flow (GVF).

The adaptive sampling scheme may comprise identifying a bounding box around an area of interest based on the extracted contour of the bone.

The bounding box may be divided into a predetermined number of sampling points.

A sampling region around the sampling points may be chosen to cover image pixel points between the sampling points.

The image processing may comprise calculating one or more texture maps of the digitised x-ray image and detecting a bone fracture based on respective reference texture maps.

The texture maps may comprise a Gabor texture orientation map.

The texture maps may comprise a Intensity gradient direction map.

The texture maps may comprise a Markov Random Field texture map.

The image processing may comprise calculating one or more difference maps between the respective texture maps calculated for the digitised x-ray image and the respective reference texture maps.

The difference maps may be classified using one or more classifiers.

The difference maps may be classified using Bayesian classifiers.

The difference maps may be classified using Support Vector Machine classifiers.

The image processing may comprise determining a femoral shaft axis in the digitised x-ray image; determining a femoral neck axis in the digitised x-ray image; measuring an obtuse angle between the femoral neck axis and the femoral shaft axis; and detecting the bone fracture based on the measured obtuse angle.

The method may further comprise calculating level lines from respective points on the contour of the bone in the digitised x-ray image and extending normally to the contour to respective other points on the extracted contour.

Determining the femoral shaft axis may be based on midpoints of the level lines in a shaft portion of the contour of the bone.

Determining the femoral neck axis may be based on the level lines in femoral head and neck portion of the contour of the bone.

In accordance with a second aspect of the present invention there is provided a system for detection of bone fractures comprising means for receiving a digitised x-ray image; and means for processing the digitised x-ray image for detection of bone fractures wherein the means for processing an adaptive sampling scheme.

In accordance with a third aspect of the present invention there is provided a system for detection of bone fractures comprising a database for receiving and storing a digitised x-ray image; and a processor for processing the digitised x-ray image for detection of bone fractures wherein the processor processes the digitised x-ray images utilises an adaptive sampling scheme.

In accordance with a fourth aspect of the present invention there is provided a data storage medium having stored theeon computer code means for instructing a computer to execute a method for detection of bone fractures using image processing of a digitised x-ray image, wherein the image processing comprises an adaptive sampling scheme.

Brief Description Of The Drawings

The accompanying drawings, which are incorporated into and constitute a part of the description of the invention, illustrate embodiments of the invention and serve to explain the principles of the invention. It is to be understood, however, that the drawings are designed for purposes of illustration only, and not as a definition of the limits of the invention for which reference should be made to the claims appearing at the end of the description.

Fig. 1a shows an x-ray image of a healthy femur with a normal neck-shaft angle illustrating processing of a digitised x-ray image according to an example embodiment.

Fig. 1b shows an x-ray image of a fractured femur with a smaller-than-normal neck-shaft angle illustrating processing of a digitised x-ray image according to an example embodiment.

Fig. 2 shows an adaptive sampling grid utilised in an example embodiment of the present invention.

Fig. 3a shows the Gabor texture orientation map of a healthy femur illustrating processing of a digitised x-ray image according to an example embodiment.

Fig. 3b shows the Gabor texture orientation map of a fractured femur illustrating processing of a digitised x-ray image according to an example embodiment.

Fig. 4a shows the intensity gradient direction at one location of an x-ray image of a human femur illustrating processing of a digitised x-ray image according to an example embodiment.

Claims

1. A method for detection of bone fractures using image processing of a digitised x-ray image; wherein the image processing comprises an adaptive sampling scheme.

2. The method as claimed in claim 1, wherein the image processing comprises extracting a contour of the bone in the digitised x-ray image.

3. The method as claimed in claim 2, wherein the extracting of the contour of the bone in the digitised x-ray image comprises applying a Canny edge detector to the digitised x-ray image.

4. The method as claimed in claims 2 or 3, wherein the extracting of the contour of the bone in the digitised x-ray image comprises applying a snake algorithm to the digitised x-ray image.

5. The method as claimed in claim 4, wherein applying the snake algorithm to the digitised x-ray image comprises creating a Gradient Vector Flow (GVF).

6. The method as claimed in any one of claims 1 to 5, wherein the adaptive sampling scheme comprises identifying a bounding box around an area of interest based on the extracted contour of the bone.

7. The method as claimed in claim 6, wherein the bounding box is divided into a predetermined number of sampling points.

8. The method as claimed in claim 7, wherein a sampling region around the sampling points is chosen to cover image pixel points between the sampling points.

9. The method as claimed in any one of the preceding claims, wherein the image processing comprises calculating one or more texture maps of the digitised x-ray image and detecting a bone fracture based on respective reference texture maps.

10. The method as claimed in claim 9, wherein the texture maps comprise a Gabor texture orientation map.

11. The method as claimed in claims 9 or 10, wherein the texture maps comprise a Intensity gradient direction map.

12. The method as claimed in any one of claims 9 to 11, wherein the texture maps comprise a Markov Random Field texture map.

13. The method as claimed in any one of claims 9 to 12, wherein the image processing comprises calculating one or more difference maps between the respective texture maps calculated for the digitised x-ray image and the respective reference texture maps.

14. The method as claimed in claim 13, wherein the difference maps are classified using one or more classifiers.

15. The method as claimed in claim 14, wherein the difference maps are classified using Bayesian classifiers.

16. The method as claimed in claims 14 or 15, wherein the difference maps are classified using Support Vector Machine classifiers.

17. The method as claimed in claim 1, wherein the image processing comprises:

determining a femoral shaft axis in the digitised x-ray image;

determining a femoral neck axis in the digitised x-ray image;

measuring an obtuse angle between the femoral neck axis and the femoral shaft axis; and

detecting the bone fracture based on the measured obtuse angle.

18. The method as claimed in claim 17, comprising calculating level lines from respective points on the contour of the bone in the digitised x-ray image and extending normally to the contour to respective other points on the extracted contour.

19. The method as claimed in claim 18, wherein determining the femoral shaft axis is based on midpoints of the level lines in a shaft portion of the contour of the bone.

20. The method as claimed in claims 18 or 19, wherein determining the femoral neck axis is based on the level lines in femoral head and neck portion of the contour of the bone.

21. A system for detection of bone fractures comprising:
means for receiving a digitised x-ray image;
means for processing the digitised x-ray image for detection of bone fractures;
wherein the means for processing the digitised x-ray image utilises an adaptive sampling scheme.

22. A system for detection of bone fractures comprising:
a database for receiving and storing a digitised x-ray image;
a processor for processing the digitised x-ray image for detection of bone fractures;
wherein the processor processes the digitised x-ray image utilising an adaptive sampling scheme.

23. A data storage medium having stored thereon computer code means for instructing a computer to execute a method for detection of bone fractures, the method comprising:
utilising image processing of a digitised x-ray image;
wherein the image processing comprises an adaptive sampling scheme.